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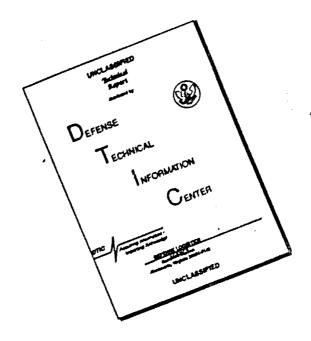
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ESTIMATED TOTAL CHAIN AND INDEPENDENT FISSION YIELDS FOR SEVERAL NEUTRON-INDUCED FISSION PROCESSES

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CHEMICAL TECHNOLOGY DIVISION L. H. Gevantran, Head

ADMINISTRATIVE INFORMATION

The work reported it part of a project sponseted by the Atomic Energy Commission, under Co. cract Number AT (49-7)-1963. The project is described in <u>USNRDL Technical Program Summary F. g. Fiscal Years 1963</u>, 1964, and 1965. I November 1962, where it is designated Program A-1, Problem 7.

Eugene P. Cooper
Eugene P. Cooper
Scientific Director

P. D. D. D. D. S. B. Roth, CAPT USN

Commanding Officer and Director

ABSTRACT

Calculated estimates are presented of unmeasured total chain yields and of independent fission yields for the fission products resulting from fission-spectrum and 14-Mev neutron bombardment of U233, U235, U235 and Pu239 and from thermal neutron bombardment of U233, U235 and Pu239.

SUMMARY

The Problem

Calculations of fission product growth and decay at early times after fission require input data, much of which has not been obtained and must be estimated.

Findings

This report presents estimates of total chain and independent fission yields resulting from a number of fission reactions based upon (1) observed or assumed chain yield distributions, (2) the nuclear charge for β stability as a function of mass number, (3) the values of the most probable charge in fission as a function of mass number and (4) the distribution of nuclear charge about the most probable value.

INTRODUCTION

The initial development of a generalized fallout model has been planned to yield early, if approximate land surface burst prediction capability. It was intended to refine the input data and to extend the model to other burst conditions. However, the sensitivity of radionuclide fractionation to the independent yields and half-lives of the primary fission products, the timely appearance of up-to-date treatments bearing upon the subject, l, 2 have led to the revision of the nuclear input data as early as possible.

This report consists of the tabulation of estimated total chain yields and independent yields for fission products resulting from the fission of U233, U235, Pu239 caused by thermal neutrons and of U233, U235, U238, and Pu239 by fission spectrum neutrons and neutrons of 14-Mev energy. These estimates while somewhat preliminary will be useful to this program as well as to many engaged in radionuclide build-up and decay calculations for programs in other areas, e.g., reactor chemistry and physics, radiobiology and operations analysis.

METHOD OF CALCULATION

The data required for determining these values were: Y_A , the fission yields in percent of each mass number A for the particular fission reaction involved, and A^T_{Z} , the fractional chain yields for each isobar of mass A for the particular fission reaction involved. The quantities of atoms reported are those resulting from the arbitrary choice of 10^{14} fissions occurring simultaneously. Therefore the number of atoms of atomic number Z and mass A resulting from 10^{14} simultaneous fissions is:

$$(A^{f}z)(\frac{Y_{A}}{100})(10^{4})$$

for the particular reaction involved.

Total Chain Yields

The values for the total chain yields, YA, were those given by Katcoff's compilation. In regions of incomplete data, yields were taken from fission yield curves constructed on the basis of available data and estimates of the amount of variation in chain yields induced by given changes in neutron energy and in mass number of the fissioning nuclide. In each case the total fissions were normalized to 200 %. The resulting curves, in units of percent, are shown graphically in Figs. 1 through 11 and additional details of estimation, when necessary, accompany each figure. The data are presented in Table 1 in units of atoms per 10⁴ fissions.

Fractional Chain Yields

The fractional chain yields, Af_Z , or fraction of the total chain yield of mass A bearing charge Z, were determined for each value of Z in the mass chain A, in the region of the most probable charge in fission, Z_p , for that mass number. The values for Z_p for thermal neutron fission of U^{235} were taken from Coryell. Unique values are not given, however, for Z_p in the neighborhood of shell and sub-shell closures and their conjugates (A = 68-71, 82-84, 98-100, 105-106, 128-130, 134-135, 149-152, 163-164, inclusive). In these cases values of Z_p were taken from a constructed linear plot connecting the extremal points of the regions of double values of Z_p . From the values so obtained for Z_p , together with Glendenin's charge dispersion curve, the values for fractional chain yield Af_Z , were found for each mass number A.

The change in Z_p , relative to that obtained in the thermal neutrous fission of U^235 , due to other fissile material and neutron energies was found through the use of Coryell's prescription²

$$\Delta Z_p$$
 (A) = $\frac{1}{2}$ (Z_c -92) - 0.21 (A_c -236) + (0.023) (E* - 6.5)

where $\Delta Z_p(A) = Z_p^*(A) - Z_p(A)$ (standard), $Z_p^*(A)$ being the value sought for given fission conditions and $Z_p(A)$ (standard) being the value of Z_p of mass chain A for thermal neutron fission of U^{235} ; and Z_p is the charge, A_p the mass, and P^* the excitation energy (in Mev) of the compound nucleus under consideration. In this manner values of the most probable charge for mass numbers found in fission for all of the cases considered were calculated.

From the above calculations and data, the number of atoms of given Z and A were calculated on the basis of 10^{14} simultaneous fissions having occurred under the various conditions enumerated. The results of these calculations are given in Table 1.

Figures 1 to 11. Fission Yield Curves for Reactions
From Verious Heutrons
(Fission = Fission Spectrum; Th = Thermal)

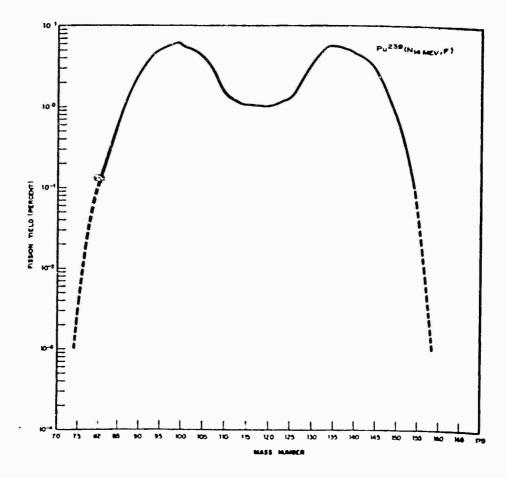


Fig. 1

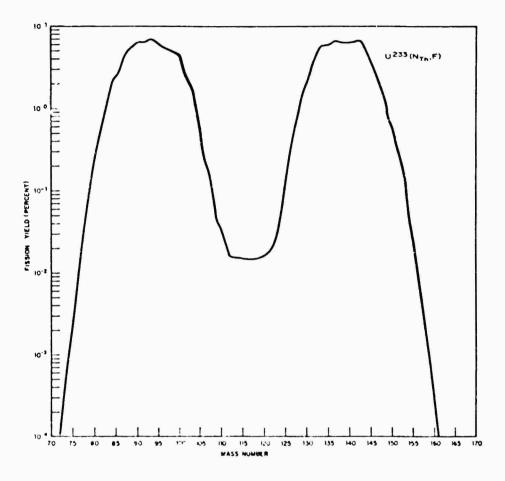
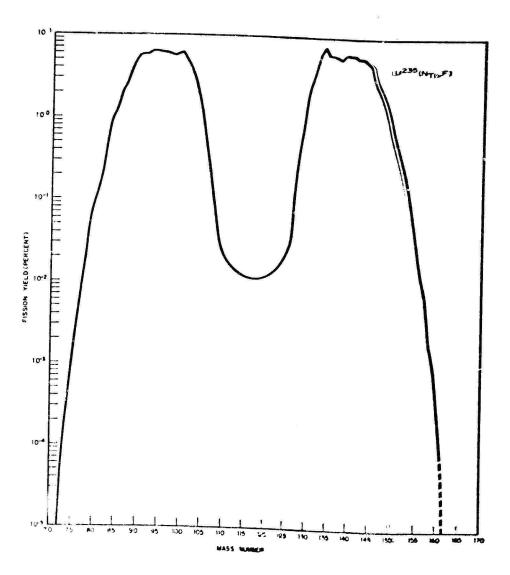


Fig. 2



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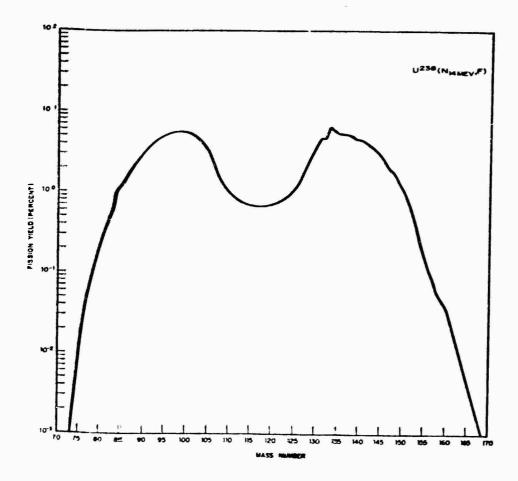


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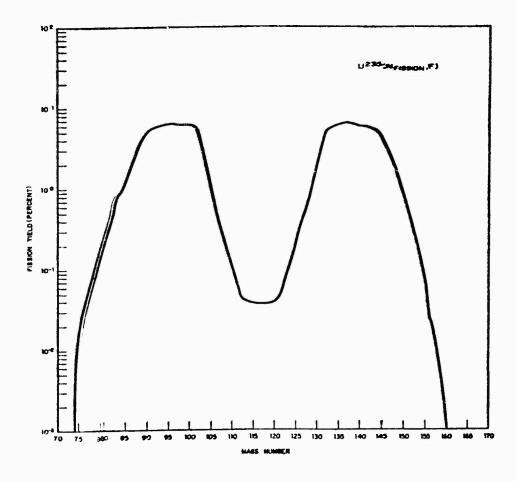


Fig. 5

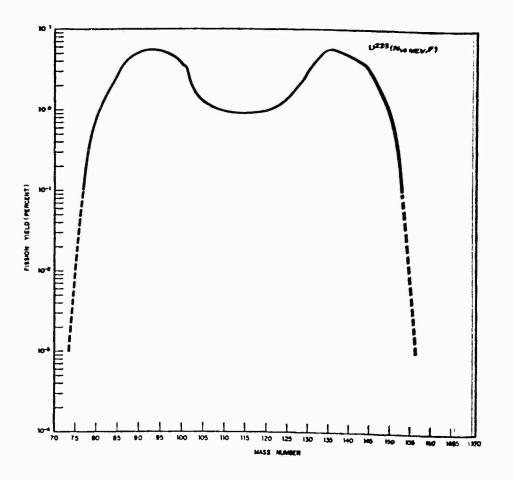


Fig. 6

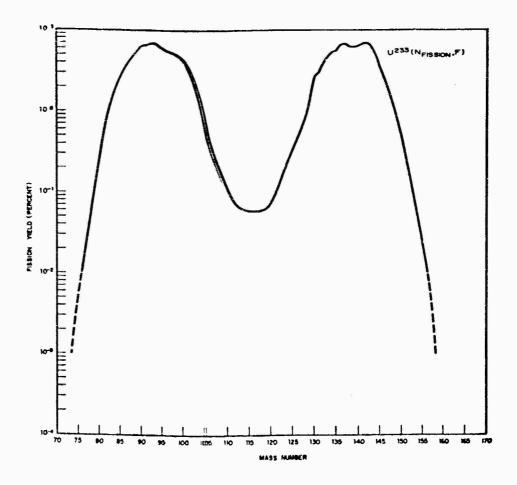
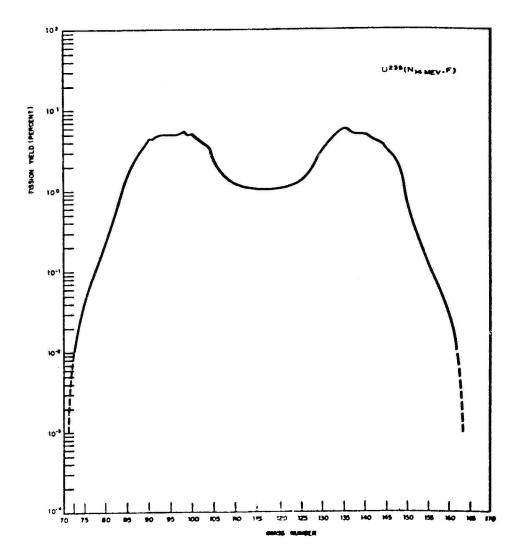


Fig. 7



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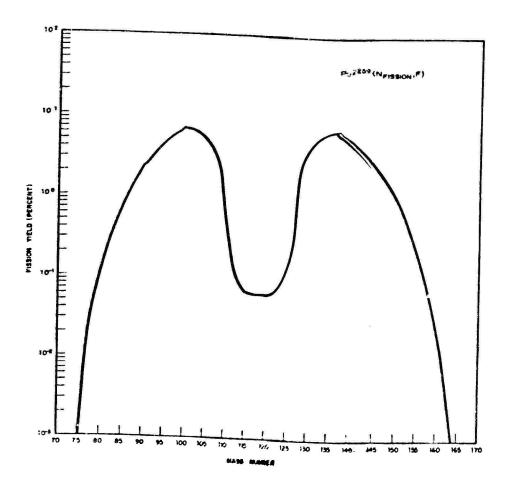


Fig. 9

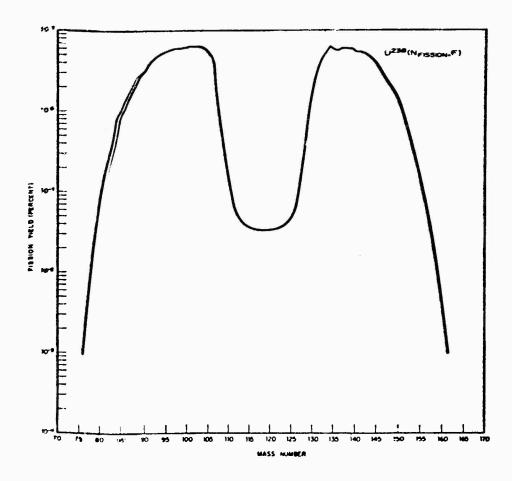


Fig. 10

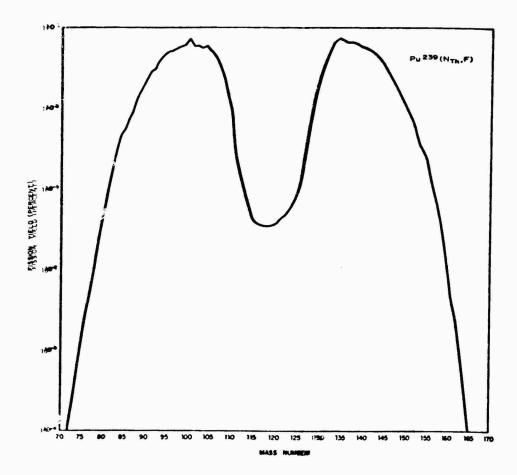


Fig. 11

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:	0.1631	60600	C+1381	0.1628	0.0000	5,3673	16.5127	690000	96040	105970	304600
4	0.4472	37,8905	C. 7185	20.4761	100017	52.8319	33 04275	105375	204136	1000	0.000
Ŷ	0.3752	43,0336	0.9297	404.604	1.5723	4465937	16.9127	1.3014	001100	00000	801308
1	0.0700	12.7020	0.3102	23 6 5 4 7 5	0.3642	18.9063	1.0701	Ca2478	01.01		10000
•	ô	0.1455	C.0039	2.8462	9	0.6353	ģ	9	90100		
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٥	1 • 0990	102.4652	F. 1024	\$0.237 0	4.0780	100.7544	10,1350	30,045	671109	303769	3:1:0
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	C2387A	THRE 27	だしついつ	せんだべつ	P239TM	34878d	C2361E	140000	12000	180460	Sec. Cont.
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:	0.11.0	4.0072	P01707	•	210100	80000	40440	244	#140.0	*****	011441
;	91910	400000	20.11.14	B497.07		10.75.35	46.400	1.02.01	-	18741	1
;	0.0013	44.1058	40.7.00	800000C	1.7318	43.3071	25.50	46.44			
-	0.46/1	4801344	004173	3303212	9014.0	38.5269	44.0	217803	>2000	1010	4444
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	U2351H	24304E	U233TM	U2334E	#239TH	P239HE	U2384	U235F1	1,0520	U238FI	PU239F
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;	09100	0.1288	•0•	?	0000	•0•	3.8300	250000	•0•	0.4578	0.0262
4	17 7 7 0	1813731	3,1501	3.9824	0.3762	913312	21.9565	G.80.0	0.6150	104228	1.0253
•	A TEAC	100	0.000	36,6316	1 1 4 2 3 3	40.3B3V	20 CO	10700	A. 4 530	E03201	2.0031
-	1497	SALLINAS	4(1/1)	40.44	240	日本つだっても	PC 40 01	24004	S. 49.34	9010 O	015704
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0	111002	1030,3264	1105-1	#1.689B	3.5825	104.6787	47,0341	3.7000	0.1370	30,100	0.3710
155 NOR	111										
	U2357H	U235HE	UZSSTH	U233HE	P239TH	P239HE	U238HE	UZBSF1	USBORY	CZJBFI	PU239F
10.4	•0•	•	•	•	•	•	•	•	•	0	•
*			0	9	9	•0•	0.8783		0	0.1674	•
17	0.1421	5,2392	0090	0.1850	C.2597	3.1917	12,8330	0,3813	0.2303	1.0260	0.4680
30	0.5742	5241393	0.4183	14.9473	1.2638	26.2248	31.1393	1 . 5251	1.7238	105293	202740
4.7	545672	47,04.59	0.7123	4242331	145223	48.3038	10.6984	000001	200325	016214	2.7613
94	1001	18.5507	043142	30,3066	204737	22,0721	200130	343701	11.221	0.0167	0.552
1		4484	00.0	2 4 4 5	99000	1.6204		0	0.0440		241040
7				,							
,	114236	104.5887	1.5251	93.2644	3.5268	102.6022	47.1814	3,7812	6.2535	9000	6.166
3	411 E30)										
	U2357A	CRUSHE	CRUSTR	V233HE	P239TH	P 239HE	0238ME	U235#1	U233F1	U238F1	PU239#
;	ំ	?	į	•	• D.	•	0	•	•0•	0.0100	•
n•	0.000	0.6215	4400.00	7,1193	0,0638	169140	6.0488	0.1474	801000	066243	0.1127
9	0.3552	16.6364	0.2322	35 • 32 1 2	0.6031	13.5190	2011650	1.00076	0.9377	100000	10.01
Ç	6: 44 0	44.3325	5404.7	4000004	1.6917	4304064	58 . 254 2	10000	070 A W	100387	743000
7	0.2901	32.0.46	303374	11.55	0.4105	32.004.9	7.4614	0.7780	400004	*****	1 . 6 24
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٠,	0:1007	163,312?	1.5713	700,000	318468	1014717	21.012	7.8413	*****	343746	114719
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44		40.4893	30 2244	£3.5470	1.0044	3203001	7.35.7	107-04	4.6.270	34240	***
ļ	0.4784	4810144	3, 71.78	469994	104330	44.554	18.4184	11771	2070F	277400	4 . 4 5 6 7
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?	777807	2001100	116201	23,2449	2.4361	5202464	255.70¢	ラグラとのか	4000	40.46.00	2041
2	30 1321	£1.1730	C4642	35.4.155	0.7533	24.65.18	3.7208	** 6484	3.9711	40000	4070
10	ż	0.6535	4050.00	5.6369	0.0100	1.9719	ġ	i	302362	0	0.013
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,	100100	121.6134	302787	114.64.9	3.623	110-6355	192915	*****	1401997	3+6794	.114
45. 4	A51 536.										
	おとびできつ	0235.€	U23374	22334E	P2397H	₱239H€	UZJBHE	U233F1	U233F1	U238F1	PU239
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*	012240	0.7469	001000	?	301244	0.2257	8.4544	0.5446	0.0741	0.7879	0.017
•	3-75-6	22.0196	~* 8126	404000	1.5623	15.7552	36.6111	308020	3.8876	1.9038	2.443
•	30 36 03	2701290	204317	47.1973	3.2434	5102566	39 . 49 62	4001.4	11.6076	1.2970	4.720
?		38.0860	1.8913	53.6473	107912	45.0817	10.5456	202021	1100.6	0.2125	2.556
ñ	0.0170	9 000	0.3393	13.5416	0.2160	60499	i	0.1461	1,7238	?	0.311
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9		54,5191	6.5946	63,9877	346429	S. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.	24.1753	0.40040	1546807	0.6408	A1744
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ñ	2000	42.4.350	B. R662	SA 0 7 1		38,1175	016416	4.7170	1208597	30110	3,2486
7	2000	40124	10100	12.6999	00000	200414	0	0.0758	001201	•	960100
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3	86 78 35		2305165	9812544	1716137	62.6144	76.6047	22,3684	24.9465	4.2007	ROLUANT.
ñ	804002		23.5165	86.4204	1108429	6715955	27.1599	12.2.07	240462	900	10.7500
ra E	100200		3.4841	33.4784	1.9408	17.8096	0.6974	1.054.81	014.710	47.	84.45
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,	13,0002		30.8012	186.3422	36.4006	162.5330	160.0786	47.8468	62,3969	1110111	34.4678
MASS M	W. 128										
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4			6.9949	6.5728	10.3443	1341124	42.4774	14.0703		0000	CA130
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.,	80.2351	314.5645	170.0190	233,7855	169.0715	245.5479	F90.9984	126,9961	136,2324	86.0850	296,360\$
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	6614206	26,2424	2142149	1.9657	80.2536	15,0437	125,3532	50.0216	000001	16246098	A04 208
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2		238.74.27	218.1667	120.01.01	337,3470	2CF - 1757	26106499	271106027	154.7704	43103314	4.B1 6 4040
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6	074.1265	65.2320		146,40,19	73,7397	100.7619	22,4840	62,5280	164.9527	10.4935	59.4970	
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2.3	16601734	138.2310	C27.1490	175.0704	155,2393	172.7993	78,3955	178.9430	227,0045	80.0304	167,9123	
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bombardment of U	. 1233 U.235, U.238 and Pu.239 and from U.235 and Pu.239.	and 14-Mev neutron bombardment of $0.^{233}$, $0.^{235}$, $0.^{238}$ and Pu 239 and from thermal neutron bombardment of $0.^{233}$, $0.^{235}$ and Pu 239 .	38 and Pu ²³⁹ and from
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